INL engineers have built a lightweight, portable device capable of detecting tunnels or weapons caches through 75 feet of solid earth.

INL tunnel detector could help shut down smugglers' routes

by Mike Wall, *Research Communications Fellow*

Idaho National Laboratory engineer Phillip West holds a curious metallic device about as wide as a steering wheel. It looks a bit like a flat, stoic face, with two large circular holes for eyes, protruding cylindrical ears and a long, disc-ended snout.

"Are we ready?" he asks, then kneels and nestles the snout gently into the dirt. West flips a switch on one of the machine's handles, and for the next eight seconds a rising tide of sound waves, strong enough to shake your shoes, floods the earth underfoot.

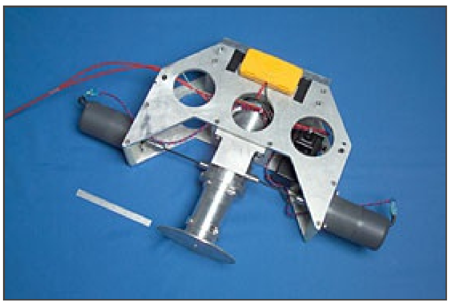
West's machine, which he calls the Look-Ahead Sensor, or LAS, is probing for tunnels, caves or other subterranean voids. This run, performed behind an INL office building in Idaho Falls, finds nothing out of the ordinary. But take the LAS to the right spot, such as certain stretches of the United States' southern border, and it would probably turn up something interesting.

And that's the idea. As security along the border has tightened recently, smuggling and human trafficking have gone increasingly underground, making good tunnel-detection technology more and more necessary. The LAS, which West presented at a recent homeland security conference, shows great promise in this regard. While still a prototype, it's portable, cheap and effective in most types of ground—a combination other detection systems have a hard time matching.

Searching the subterranean

More than 100 border tunnels have been discovered since 1990, 23 in 2008 alone. Some of these contraband conduits are incredibly elaborate, the work of sophisticated criminal syndicates. In 2006, for example, officials unearthed a 2,400-foot-long tunnel connecting a Tijuana industrial building to a San Diego warehouse. According to the San Diego Union-Tribune newspaper, the tunnel went 85 feet down at its deepest point, and its builders, likely a Mexican drug-smuggling organization, outfitted it with ventilation and pumps to clear out seeping groundwater.

Anything could be coming into the U.S. through these tunnels—people, drugs, weapons—so underground passages pose an obvious national security risk. But effective, proven tunnel-detection technology has yet to be deployed along the Mexican border. All tunnels discovered to date have been found by luck—such as a truck sinking through a shallowly dug section—or old-fashioned detective work.



The Look-Ahead Sensor, or LAS, weighs

The LAS, developed by West and fellow INL engineers Stephen Novascone and John Svoboda, is one possible solution. The LAS transmits acoustic waves into the earth, starting at around 50 cycles per second, or hertz. Over the course of one eight-second run, the frequency ramps up to about 200 hertz. While this is happening, an onboard motion detector measures how the waves shake the dirt and rock through which they pass. The LAS exports these values to a laptop computer, where special software can graph and analyze them.

just 25 pounds and is powered by off-the-shelf rechargeable batteries.

When the assayed earth is solid, the resulting graph shows a rapidly rising line: as frequencies increase, the soil shudders more and more violently, in a continuous and predictable fashion. But if there's a void underfoot, the graph shows a humped peak or dip. This is because sound waves hitting empty space tend to behave differently. They either amplify or interfere with each other, causing a spike or drop on the graph. Once the LAS detects a void, the laptop figures out how far away it is in a matter of seconds using a mathematical formula that links frequency, the speed of sound and distance.

INL engineer Phillip West holds the LAS in a vacant lot behind an INL office building in Idaho Falls.

The LAS versus other technologies

LAS's acoustic approach isn't the only way to find a tunnel; engineers around the country and world are trying other tacks. One of these is ground-penetrating radar, which archaeologists and civil engineers have used since the 1970s. Other groups are investigating microgravity, the tiny differences in gravitational fields caused by subsurface voids. Electrical currents can't span empty space, so some engineers are experimenting with electrodes buried underground. And scientists in Israel, concerned about the hundreds of smugglers' tunnels connecting Gaza to Egypt, have developed a fiber-optic system. Buried cables can detect even tiny movements of nearby soil particles, indicating digging activity.

All of these methods have substantial drawbacks, however. Ground-penetrating radar goes down only 40 feet or so in the best of conditions, and it does not work well in clay or moist soils. Microgravity equipment is expensive and must be held perfectly level, and at a constant temperature, when taking readings. A stationary tunnel-detecting electrode system would be huge, costly and prone to tampering. And the Israeli fiber-optic technique only detects digging, not existing tunnels.

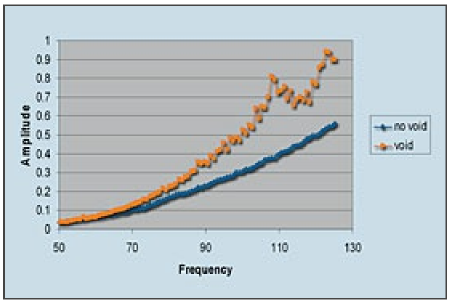
Yet the LAS works in sandy or rocky soil, dry ground or wet. West has put the machine to the test, successfully identifying a trench through a 75-foot-thick section of hillside at INL's desert Site 40 miles west of Idaho Falls. This May, he gave a presentation on the LAS at the International Conference on Technologies for Homeland Security in Boston. The meeting was organized by IEEE (formerly the Institute of Electrical and Electronics Engineers, Inc.), the world's premier engineering and technology professional association.

"The response was pretty favorable," West says.

Further, the machine is portable—it weighs only 25 pounds or so—and relatively cheap. West estimates that only a few thousand dollars of parts and labor went into building the LAS prototype, so its sale price down the road should be quite reasonable. Its 48 nickel-metal hydride batteries, bought off the shelf at Batteries Plus, can probably power at least 100 eight-second runs before they need a recharge.

And the LAS is easy to use. The software spits out a graph of each run in seconds, meaning tunnels or weapons caches could be detected and mapped almost in real time. In fact, West says on one run he could tell that a void lay beneath him just by how the machine felt in his hands. The results confirmed his hunch: he'd operated the LAS over a vertical vent-line pipe buried about 15 feet deep.

What's ahead for the LAS



A tunnel shows up as a spike or dip on a graph plotting soil movement ("amplitude") against acoustic wave frequency. View the amplitude and frequency chart.

Despite its successes, the LAS remains a prototype, and West is hoping to attract more funding to improve its design and performance. For one thing, he'd like to incorporate the LAS's three separate computer programs—one for collecting data, one for calculating frequencies and one for graphing—into a single software package. That, along with a hoped-for user interface with a "Void/No Void" and "Distance" display, would render the attached laptop unnecessary.

"It's very doable, with the right programming," West says.

He envisions the LAS potentially mounted on an autonomous vehicle, picking its way through the creosote flats and saguaro-studded slopes of the border country, pausing every 30 seconds or so to take a reading. On the dusty streets of border towns, human operators could use it to look for urban tunnels. But West also sees other applications for the technology, including mining and oil and gas exploration. And he hopes to build a mini-LAS, about the size of a flashlight, which would specialize in finding holes and caverns relatively close to the surface.

"Most of the time, when people want to find something underground, it's something like a septic tank," he says. "'Where's that septic tank?' Think how useful that little tool would be."

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NOTE: This technology has reached the end of its development cycle and is not a candidate for licensing.

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